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FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's	)	ET Docket No. 98-153
Rules Regarding Ultra-Wideband	)	
Transmission Systems	)	

COMMENTS ON NTIA NON-GPS INTERFERENCE STUDY

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Fantasma Networks, Inc. ("Fantasma") hereby submits comments on the Non-GPS interference study (the "Non-GPS Study") recently completed by the National Telecommunications & Information Administration ("NTIA"), which now has been made part of the record in the above-captioned proceeding.

INTRODUCTION AND SUMMARY

As evidenced by comments filed to date in this proceeding, there is widespread support for amending the Part 15 rules to permit deployment of ultra-wideband (UWB) technologies. UWB has the potential to revolutionize how people live, work, and interact. Public safety groups, educators, medical organizations, groups representing the elderly and disabled, federal and local government agencies, and other potential users and beneficiaries of UWB technologies have filed comments and letters supporting the Commission's proposals. Each of these parties has recognized the numerous benefits that could be realized from this new broadband transmission technology.

The release of the Non-GPS Study on the potential for UWB devices to interfere with non-GPS government radio system marks another significant milestone in the effort to enable UWB technologies. NTIA quite rightly took a

cautious approach in its analysis, given the fact that no one has actual experience regarding the co-existence of UWB and non-UWB radio systems in operating environments. There is, however, a cumulative progression of "worst case" assumptions in the Non-GPS Study that tends to overstate the risk of harmful interference to other spectrum users. Fantasma has compensated for this effect, while still taking a most cautious approach to the analysis. This results in a realistic improvement in the prospects for co-existence between UWB radios and non-GPS radios in broad ranges of frequencies above 2 GHz without a risk of harmful interference.

These comments begin with an overview of the NTIA results in order to establish a baseline for Fantasma's analysis. The Fantasma analysis then builds on that baseline and, through quantitative analysis of the NTIA models, demonstrates that the interference potential of UWB technologies is, in fact, lower than suggested by the Non-GPS Study. In addition, these comments address certain operational assumptions underlying the NTIA study and shows that, using more realistic assumptions, there is even a greater likelihood that UWB technologies will not pose a threat of harmful interference to other users of the radio spectrum.

DISCUSSION

I.   BASELINE OF THE NON-GPS STUDY.

NTIA examined potential interference from UWB devices into government radio systems operating across a range of frequencies from 960 MHz to 5650 MHz, but excluding GPS frequencies. NTIA also considered a variety of UWB operating conditions, including variations in UWB pulse repetition

frequency, transmitter antenna height, and signal dithering.[1] To simplify the
analysis, these comments focus on the following subset of conditions, which
reflect operating conditions in a UWB communications network:

- operation above 2 GHz
- pulse repetition frequency of approximately 10 MHz
- worst-case conditions for dithered vs. non-dithered UWB signals[2]

Figure 1 shows the baseline NTIA interference analysis for a single UWB
emitter. The graph shows signal amplitude on the vertical axis. The horizontal
axis of this graph is placed at -41.3 dBm/MHz, which is the UWB emission limit
proposed by the Commission in the Notice of Proposed Rulemaking ("NPRM").
Bars above this axis indicate that further mitigation, in addition to the NPRM
emission limit, is necessary to ensure that UWB signals remain below the victim
receiver interference threshold, as defined in the Non-GPS Study.

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[1] NTIA proposes to measure the output of UWB emitters using an "RMS" technique that
differs substantially from the more traditional method proposed for UWB devices by the
FCC in the NPRM. Fantasma has compared the two measurement techniques. Our
preliminary conclusion is that, at the relatively high pulse repetition frequencies typical
of UWB communications devices, either measurement approach is appropriate.

[2] The NTIA's use of UWB signal dithering serves as an approximation of the various
methods of modulating a UWB signal. In a communications network, signal modulation
level varies depending on the information being transmitted. An actual UWB signal in a
communications network can most closely resemble either a dithered or non-dithered
test signal, depending on the type and level of actual signal modulation. Moreover,
whether a victim receiver is more sensitive to dithered or non-dithered UWB signals
depends on many factors specific to the victim receiver. Therefore, in analyzing NTIA
data for both dithered and non-dithered UWB signals, Fantasma chose the signal type
that yields the greatest potential for harmful interference to a given government system.
In this manner, the analysis is based on worst-case conditions.

Figure 1: Worst-Case Interference Threshold (NTIA Data)

Assumptions: 10 MHz PRF, frequency > 2 GHz, worst case (dithered vs. non-dithered).
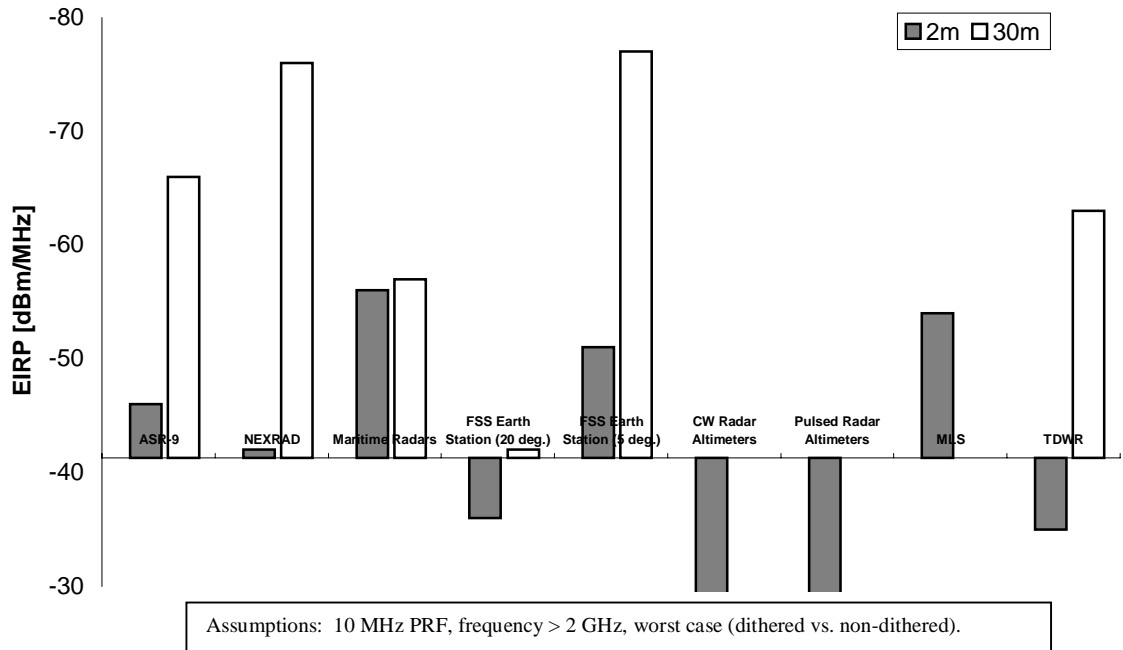
II.   THE NON-GPS STUDY DID NOT ACCOUNT FOR CERTAIN MITIGATION FACTORS

The NTIA Non-GPS Study does not take into consideration a variety of technical and operational factors that will serve to mitigate the interference potential of UWB. In particular, NTIA did not take into account that UWB transmissions will be required to meet a 20 dB peak-to-average power limit, will most likely not be operating out-of-doors at high elevations, and will suffer propagation losses from terrain, buildings, vegetation, and other natural and man-made obstructions. The following analysis accounts for these factors and shows in Figures 2, 3, and 4 the cumulative effect of these mitigating factors.[3] At the end of this Section, Table I shows the cumulative effect of these factors for a

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[3] This discussion is not intended to promote the use of specific numerical mitigation factors, but to suggest that these factors can and should be quantified in examining potential interference from UWB devices.

broader range of UWB operating conditions than shown in Figures 2, 3, and 4. Table I shows that, for almost all conceivable UWB operating conditions examined in the Non-GPS study , UWB devices that comply with the FCC's emission limit will not pose a threat of harmful interference. As discussed in Section III below, the few government systems that are shown in Table I as requiring further protection will be protected by the conditions under which they and UWB systems can be expected to operate.

A.   Limits on Peak Emissions

The Non-GPS Study assumes no limit on peak-to-average power emission for UWB devices. This assumption does not take into account the FCC's proposed 20 dB peak-to-average power limit for UWB transmissions, which Fantasma, and all UWB companies of which Fantasma is aware, support.[4] Factoring this power limit into the NTIA interference analysis results in substantially increased protection for other spectrum users.

1.   NTIA Methodology

NTIA applied a limitation only on *average* UWB emission level – not on peak levels. NTIA determined average UWB emission power in a 1-MHz resolution bandwidth. In accordance with the FCC's proposed approach, however, NTIA determined *peak* power in a 50-MHz resolution bandwidth.[5]

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[4] "Comments of the Ultra-Wideband Working Group," filed December 7, 1998 in response to the FCC's Notice of Inquiry. These comments assumed both peak and average power to be measured in a 1-MHz resolution bandwidth.

[5] As Fantasma showed in its reply comments in this proceeding, it is not necessary to measure the peak power in 50-MHz resolution bandwidth Current Part 15 measurement techniques, employing a 1-MHz resolution bandwidth, are adequate to protect even wider bandwidth victim receivers. Nevertheless, our current analysis builds on NTIA's measurement approach.

Figure D-1, taken from the Non-GPS Study, shows that NTIA calculated
the predicted peak emission level in a 50-MHz bandwidth with the average
signal power limited as proposed in the NRPM and measured in a 1-MHz

Figure D-1 From Non-GPS Study
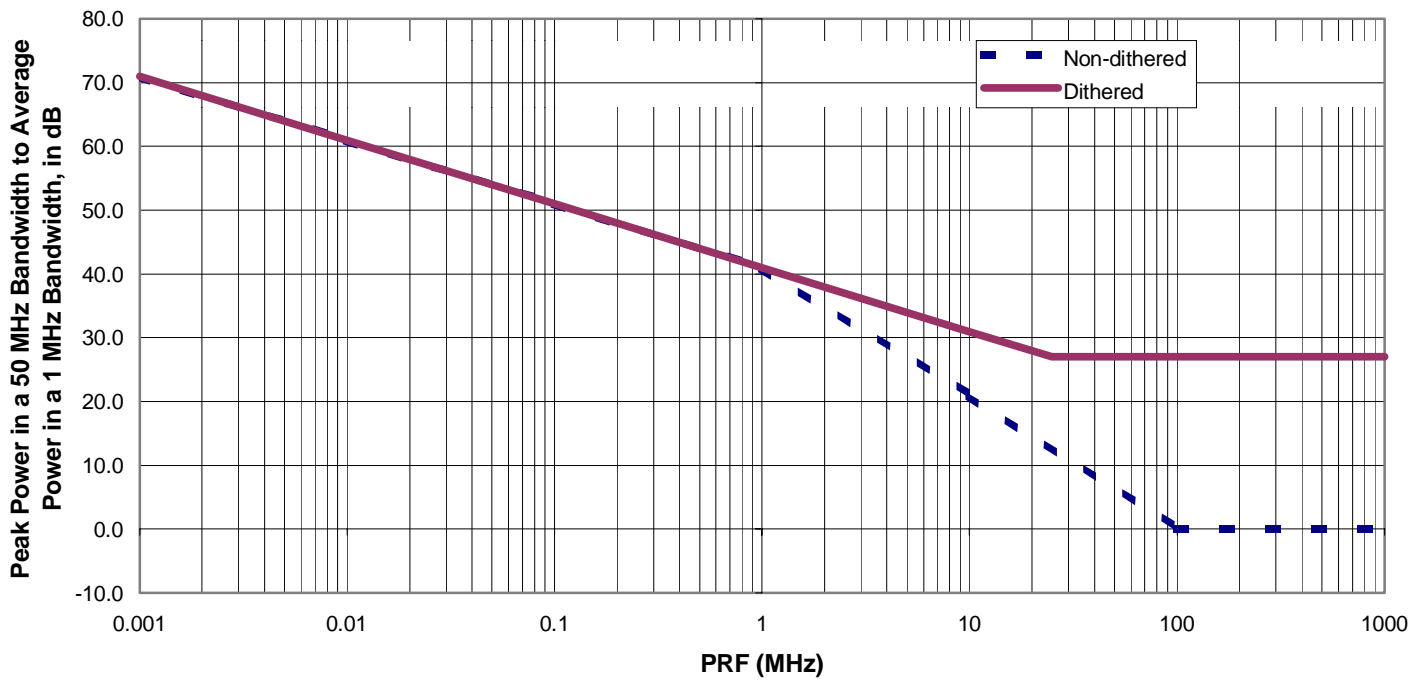
bandwidth. For example, referring to Figure D-1, NTIA predicts that a UWB
emitter with a 100 KHz PRF would show a peak power in a 50-MHz bandwidth
of about 51 dBm above average power in a 1-MHz bandwidth.

2. Application of a 20dB Peak-to-Average Power Limit

As noted above, the FCC has proposed a 20 dB peak-to-average power
limit for UWB transmissions. Application of this limit to the NTIA interference
calculations shows that there would be significantly less potential interference to
other spectrum users.

For example, referring to the same case from Table D-1, taking into account this 20dB peak-to-average limit, the peak power would fall from 51dB to 20dB above average power – a reduction of 31dB. As a consequence of this change, the average power also would fall by 31dB. Figure 2 modifies Table D-1 to incorporate the 20dB peak-to-average limit for a UWB device operating at 10 MHz pulse repetition frequency, which is the most appropriate frequency for examining the effects of UWB communications networks.

These adjustments provide up to 11dB of additional protection to non-UWB radios. Figure 2 shows signal amplitude on the vertical axis. The horizontal axis of this graph is placed at -41.3 dBm/MHz – the UWB emission limit proposed in the NPRM. Bars above this axis indicate that further mitigation is necessary, in addition to the NPRM emission, limit to ensure that UWB signals remain below the victim receiver interference threshold defined in the Non-GPS Study.

Figure 2: Worst-Case Interference Threshold (NTIA Data with 20dB Peak/Average Limit)

Assumptions: 10 MHz PRF, frequency > 2 GHz, worst case (dithered vs. non-dithered).
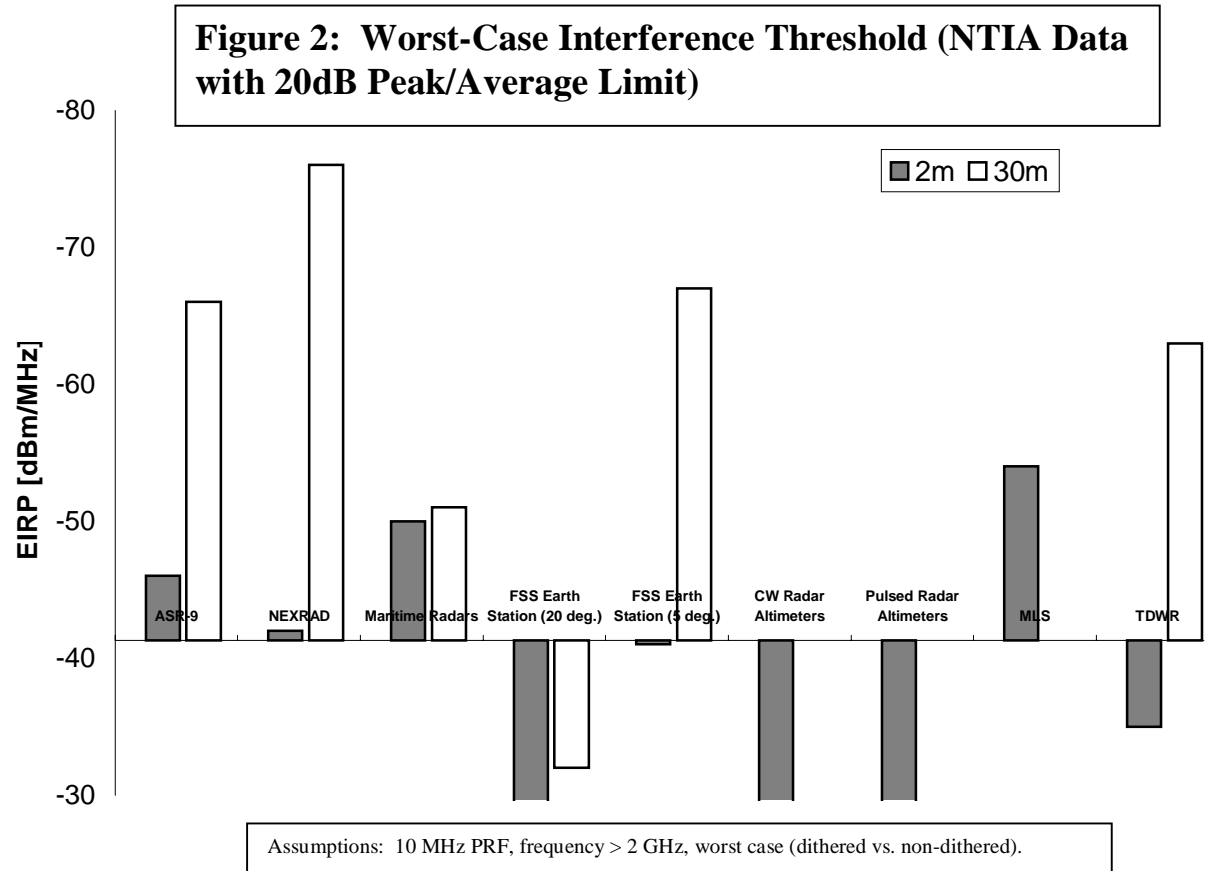
B.   Realistic Usage Scenarios at 30m UWB Antenna Height

NTIA analyzed potential interference from a single UWB radio in two operating situations: when the UWB antenna height is two meters and when it is at 30 meters. NTIA's analysis shows that UWB devices pose a greater potential for harmful interference at 30-meters antenna height than at two meters, given the geometry of the victim receivers and the fact that greater antenna heights generally increase the chance of line-of-site transmission to the victim-receiver.

In practice, however, the vast majority of UWB systems with an antenna height in the 30-meter range will be indoors. This is because most UWB

communications applications will take the form of short-range communications networks. In such communications networks, UWB devices will operate at distances up to approximately 100 feet. That range is adequate to provide networking within homes, schools, and libraries, but it is too limited to serve outdoor, "building-to-building" networks.

If indoor operation is assumed, then, as the Non-GPS Study suggests, there will be additional signal attenuation. In the Non-GPS Study, the NTIA uses building correction factors of 9 dB for frequencies from 2000-3000 MHz, and 12 dB for frequencies from 3000-5650 MHz.

Applying NTIA's building correction factors, Fantasma has recalculated potential interference from a single UWB emitter for antenna heights of 30 meters. Figure 3 shows interference thresholds for various government systems, applying both the building correction factor for the 30 meter case and the peak-to-average power limit described above. Figure 3 shows signal amplitude on the vertical axis. The horizontal axis of this graph is placed at -41.3 dBm/MHz – the UWB emission limit proposed in the NPRM. Again, bars above this axis indicate that further mitigation is necessary in addition to the emission limit.

Figure 3: Worst-Case Interference Threshold (NTIA Data with Building Attenuation & 20dB Peak/Average Limit)

Assumptions: 10 MHz PRF, frequency > 2 GHz, worst case (dithered vs. non-dithered).
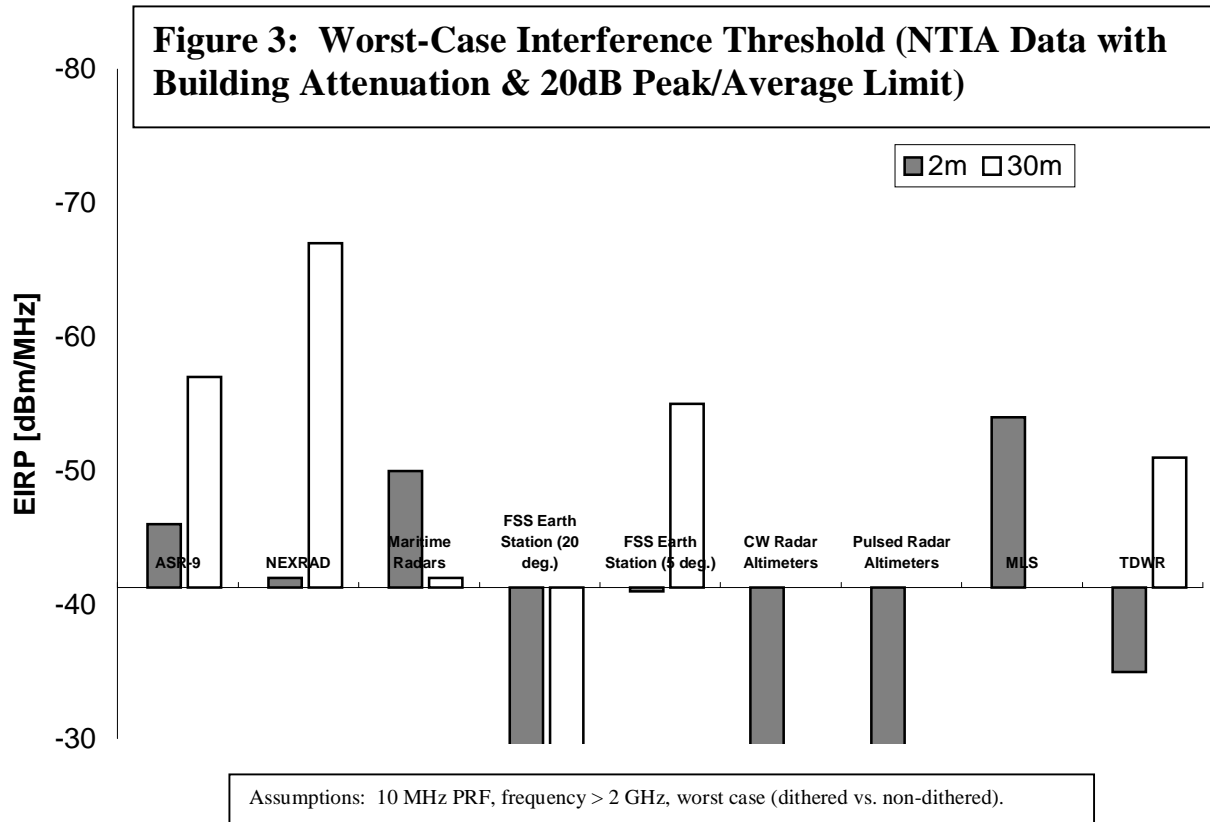
C.   A More Realistic Propagation Model

NTIA's analysis of potential UWB interference is based, in part, on signal propagation data derived from an Irregular Terrain Model (ITM) described in the Non-GPS Study. Fantasma has determined, however, that the ITM assumes free-space signal propagation over substantial distances. As is generally agreed in the literature on signal propagation, such an assumption does not represent real-world conditions. In actual operation, any radio signal propagating over substantial distances will undergo significant attenuation beyond that predicted by a free-space model – even without taking into account obvious obstructions such as buildings and hills.

There are a number of propagation models that could have been used in the NTIA analysis, including the commonly used Okumura-Hata model, that would have been more reflective of UWB operating conditions. For its analysis, Fantasma chose a propagation model that is more conservative than Okumura-Hata and still produced results in which the predicted interference levels were significantly lower than those produced by NTIA.

1.   Okumura-Hata Model

The Okumura-Hata propagation model, which was referred to in the Non-GPS Study but not used in the analysis, is commonly used in a variety of applications to estimate more realistic propagation losses than a free-space model would yield. The Okumura-Hata model can result in up to 30dB more signal loss than a free-space model and is generally applied under the following assumed conditions:

- 35 meter antenna height
- frequencies lower than 2 GHz
- propagation distances between one and 30 kilometers

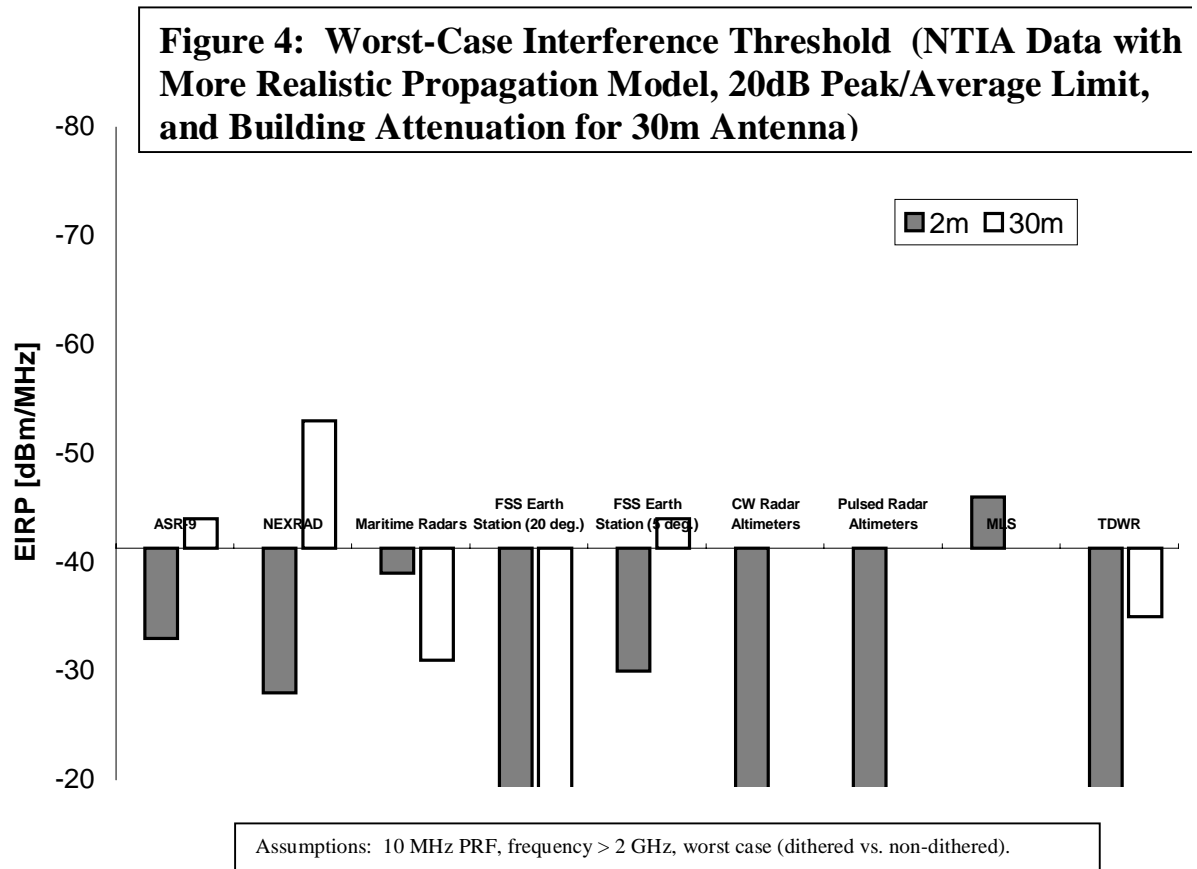Moreover, path loss increases with lower antenna heights and with higher frequencies.

2.   Re-Estimation of Path Losses

Because of the assumptions upon which it is based, the Okumura-Hata model is not ideal for examination of signals above 2 GHz. Although it might be possible to construct a modified Okumura-Hata model to account for frequencies above 2 GHz, Fantasma opted for a simpler approach:

Assume a propagation coefficient of 2.5. In other words, whereas a free-space model assumes signal strength falls with the square of the distance (R^2), assume instead that signal strength falls by a factor of $R^{2.5}$. This simplified approach results in propagation losses greater than that of a free-space model, but less than what would result from use of the Okumura-Hata model. Using a propagation coefficient of 2.5 thus yields results that are more realistic than those in the Non-GPS Study, yet suitably conservative in providing confidence that non-UWB systems will remain free from harmful interference. [6]

Figure 4 shows the NTIA data re-calculated for a propagation coefficient of 2.5, along with the adjustments described previously for the peak/average power limit and in-building attenuation. Figure 4 shows signal amplitude on the vertical axis. The horizontal axis of this graph is placed at -41.3 dBm/MHz – the UWB emission limit proposed in the NPRM. The results show substantially reduced potential for interference to other spectrum users.

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[6] "Wideband outdoor channel sounding at 2.4 GHz," Healey, A; Bianchi, CH; Sivaprasad,K. 2000 IEEE-APS Conference On Antennas And Propagation For Wireless Communications. 2000. p.95-98 IEEE, NEW YORK.

Figure 4: Worst-Case Interference Threshold (NTIA Data with More Realistic Propagation Model, 20dB Peak/Average Limit, and Building Attenuation for 30m Antenna)

Assumptions: 10 MHz PRF, frequency > 2 GHz, worst case (dithered vs. non-dithered).

The preceding analysis shows that, in almost all cases, adjustments for a peak/average power limit for UWB signals, the effects of indoor operations in buildings at 30-meters antenna height, and a more realistic signal propagation model will substantially reduce the predictions of harmful UWB interference to other spectrum users. These adjustments represent the conditions in which UWB technologies actually will operate.

Table 1 shows the cumulative effect of all these factors for a broader range of UWB operating conditions than shown in the preceding bar graphs. The table is derived from Table 1 of the Non-GPS Study Executive Summary, with maximum EIRP's adjusted to include the factors examined in the preceding analysis.

Table 1: Summary of Analysis

System	Freq. (MHz)	UWB PRF (MHz)	UWB Height 2 Meters		UWB Height 30 Meters	
			Non-Dithered	Dithered	Non-Dithered	Dithered
			Max. EIRP to Meet Protect. Criteria (dBm/MHz (RMS))	Max. EIRP to Meet Protect. Criteria (dBm/MHz (RMS))	Max. EIRP to Meet Protect. Criteria (dBm/MHz (RMS))	Max. EIRP to Meet Protect. Criteria (dBm/MHz (RMS))
Airport Surveillance Radar (ASR-9)	2700-2900	0.001	20	20	9	9
		0.01	10	10	-1	-1
		0.1	0	0	-11	-11
		1	-10	-10	-21	-21
		10	-33	-20	-44	-31
		>=100	-33	-24	-44	-36
Next Gen Weather Radar (NEXRAD)	2700-2900	0.001	26	26	1	1
		0.01	16	16	-9	-9
		0.1	6	6	-19	-19
		1	-4	-4	-29	-29
		10	-28	-14	-53	-39
		>=100	-28	-18	-53	-43
Maritime Radars	2900-3100	0.001	6	6	14	14
		0.01	-4	-4	4	4
		0.1	-14	-14	-6	-6
		1	-24	-24	-16	-16
		10	-39	-34	-31	-26
		>=100	-39	-38	-31	-30
FSS Earth Station (20-deg. Elevation)	3700-4200	0.001	26	26	32	32
		0.01	16	16	22	22
		0.1	6	6	12	12
		1	-4	-4	2	2
		10	-15	-14	-9	-8
		>=100	-9	-18	-3	-12
FSS Earth Station (5-deg. Elevation)	3700-4200	0.001	11	11	-3	-3
		0.01	1	1	-13	-13
		0.1	-9	-9	-23	-23
		1	-19	-19	-33	-33
		10	-30	-29	-44	-43
		>=100	-24	-33	-38	-47
CW Radar Altimeters at minimum altitude	4200-4400	0.001	76	76		
		0.01	66	66		
		0.1	56	56		
		1	35	35		
		10	14	25		
		>=100	14	21		

System	Freq (MHz)					
	4200-4400	0.001	76	76		
		0.01	66	66		
		0.1	56	56		
Pulsed Radar Altimeters at Minimum Altitude		1	35	35		
		10	14	25		
		>=100	14	21		
	5030-5091	0.001	14	14		
		0.01	4	4		
		0.1	-6	-6		
Microwave Landing System		1	-16	-16		
		10	-46	-26		
		>=100	-46	-30		
	5600-5650	0.001	32	32	16	16
		0.01	22	22	6	6
		0.1	12	12	-4	-4
Terminal Doppler Wx Radar (TDWR)		1	2	2	-14	-14
		10	-19	-8	-35	-24
		>=100	-19	-12	-35	-28

Table I shows that, for almost all conceivable UWB operating conditions examined in the Non-GPS study, UWB devices that comply with the FCC's emission limit will not pose a threat of harmful interference. Table I shows a small number of operating conditions in which interference thresholds for victim receivers appear to be exceeded even when UWB devices operate at the FCC's proposed emission limit. Actual operating conditions, however, will make it highly unlikely that these remaining government radio systems – mainly radar systems – will suffer interference from real-world UWB communications systems.[7] The radar applications are examined below.

III.   OPERATING CONDITIONS OF GOVERNMENT RADAR SYSTEMS FURTHER MITIGATE THE RISK OF UWB INTERFERENCE.

[7] Interference from a UWB radio at 30 meters to a satellite C-band receive earth station at a 5 degree elevation angle is the one non-radar application that is still above the FCC's proposed emission limit. Given the predominant use of C-band receive stations in the U.S. to receive video signals from satellites in the U.S. domestic geostationary satellite arc, a 5-degree elevation usage scenario is extremely rare.

In addition to the "quantitative" factors discussed above, Fantasma also has examined a number of conditions under which government radar systems operate, which were not addressed by NTIA. When these operating conditions are taken into account, one can conclude that there is probability that UWB devices can co-exist with such radar systems without causing harmful interference.

A.   <u>Antenna Coupling</u>

The NTIA data suggest that the potential exists for UWB signals to exceed the protection criteria for both NEXRAD and ASR-9 radar systems when the UWB emitter and victim receiver antennas are aligned for maximum antenna coupling. This condition occurs only in the case in which the UWB device's antenna is directly in the main beam of the victim radar receiver antenna. Receiver antennas in these radar systems are highly directional. Antenna gain falls rapidly off axis, such that at 5° off center, gain is approximately 35 dB below maximum sensitivity. Thus, when a UWB emitter is off axis with respect to the receiver antenna, the potential for harmful interference is far lower than the NTIA data suggest.

Moreover, when a UWB emitter is within the main beam of the victim receiver antenna, the return energy of the primary target will exceed the UWB emitter signal strength within the range gate of the primary return, with no direct reduction in sensitivity. In principle, any EMI emitter with a periodic signal, either UWB or CW, may contribute to multiple false targets by contributing false returns in additional range gates. In practice, however, this effect is mitigated in the radar system's interference rejection and clutter reduction processing, and the false targets will not correlate with targets of interest. While this filtering can reduce receiver sensitivity, it is likely that a

UWB radio operating within the FCC-proposed EIRP limits will not increase the loss already incurred through filtering for ground clutter and existing EMI.

Finally, in operation, victim receiver antenna tilt (elevation) angle will also reduce the potential for UWB devices to cause harmful interference. For the NEXRAD system, typical antenna tilt angles of 0.5 degrees account for a 2 dB minimum reduction in received energy for a ground-based UWB emitter, as cited in Figure A-2 of the Non-GPS Study.

B.   Processing Factors

NEXRAD uses interference rejection filters that are designed to remove typical EMI profiles. For pulse repetition frequencies greater than the IF bandwidth of the NEXRAD, a UWB emitter is equivalent to a CW signal at the receiver, and thus consistent with existing EMI profiles. Thus, the NEXRAD EMI filtering algorithms would eliminate such a UWB signal.

Radar systems such as NEXRAD and ASR-9 also filter undesirable signals by correlating (*e.g.*, averaging) multiple signal returns to distinguish actual target objects from general noise. Moreover, return shaping filters are used to differentiate between target returns and EMI. While these filtering mechanisms were developed to reduce the effects of CW interference, the mechanisms will be equally effective in filtering any potential UWB signal artifacts.

Radar systems achieve additional mitigation through "de-clutter" mechanisms implemented to remove false returns associated with objects that are relatively motionless, as would be typical for a UWB device operating in a communications network. Literature shows that de-clutter techniques employed

by systems such as NEXRAD can reduce ground clutter by at least 30 dB.[8]   This reduction would also apply to UWB emitters, and thus the potential for harmful interference would be substantially reduced.

C.   Operational Considerations

The NTIA data suggest that UWB devices could pose a threat of harmful interference to NEXRAD radar systems when the UWB device antenna height is 30 meters in elevation. Consideration of the physical location of NEXRAD systems with respect to the likely locations of UWB devices, however, suggests that NEXRAD systems are highly unlikely to suffer from harmful interference.

NEXRAD systems are located primarily in rural areas, with a typical antenna height of about 28 meters. At a 30-meter antenna height, the UWB emitter antenna is at approximately the same height as the NEXRAD antenna and thus transmission coupling between the two devices is nearly "worst case" in the NTIA analysis. Further analysis suggests, however, that the likelihood of such "worst case" conditions occurring is extremely remote. For a UWB antenna to be located at a height of 30 meters, that the antenna would likely be either inside a building or on a hill of at least 30 meters in height. Buildings of such height (equivalent to about 10 stories), however, are unlikely to be located in rural areas near NEXRAD systems.

Moreover, if a NEXRAD system is located near a hill, the system would be adjusted to compensate for radar signal reflections from the hill, such that the system essentially "ignores" the hill, rather than interpreting the reflection as a signal of interest. Such adjustments would also tend to attenuate other signals emanating from the hill – including a UWB signal emitted from a device at that

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[8] "WSR-88D Clutter Suppression and Its Impact On Meteorological Data Interpretation," Joe N. Chrisman, Donald M. Rinderknecht, Robert S. Hamilton, NOAA WSR-88D Operational Support Facility, Operations

location. As a result, UWB systems with antennas at 30 meters are highly
unlikely to cause harmful interference to NEXRAD systems.

Similar operational considerations make it unlikely that there will be
harmful UWB interference to ASR-9 radar systems, which are operated at
airports. Here too, the NTIA data indicate that UWB devices pose the greatest
potential for harmful interference with these airport radars when the UWB
emitter antenna is at a height of 30 meters. For a UWB antenna to be located at a
height of 30 meters, however, the UWB device would likely be either in a
building or on a hill of at least 30 meters in height. But, for obvious safety
reasons, 10-story buildings are unlikely to be located near airports and airports
are generally not located near significant landscape features such as hills. Thus,
it is highly unlikely that a UWB device antenna could be both at 30 meters and
near an airport.

IV.   NTIA HAS OVERESTIMATED UWB DENSITIES

When accounting for the "aggregate" interference effect of multiple of
NTIA erred in predicting much greater densities for UWB transmitters than
reasonably can be expected. For example, Table 5-7 of the Non-GPS Study shows
that for FSS Earth Stations, a UWB device density of 500 per square kilometer
will yield an aggregate UWB signal equal to a single "worst-case" UWB device,
as described elsewhere in the Non-GPS Study. Similarly, for maritime radars,
NTIA projects a UWB device density "threshold" of 200 per square kilometer.
There is, however, little chance that, within any relevant time frame, UWB
density will reach such a high levels.

Fantasma compared these assumed UWB densities with anticipated
densities derived from market projections for sales of UWB devices in urban,

Training Branch, January 1995.

suburban, and rural areas. Since urban areas are likely to include the highest densities of UWB devices, they represent "worst-case" conditions when evaluating the potential interference from the aggregate effect of multiple emitters. Such worst-case conditions are illustrated by Fantasma's estimates for density of home networking devices in Boston, Massachusetts.

Fantasma's analysis assumes a future household market penetration of 15 percent and that a typical UWB home network will contain six UWB devices. Based on these projections and the available U.S. Census data, Fantasma estimates that, when UWB technology achieves full deployment, there will be approximately 180 UWB devices per square kilometer in the Boston metropolitan area.[9] In suburban and rural areas, where population and household densities are much lower, UWB device densities will be far lower. For example, in Abeline, Texas, with a population of about 120,000, Fantasma estimates only about 18 UWB devices per square kilometer.

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[9] U.S. Census Bureau data for the Boston metropolitan area:

- Population: 4,171,643
- Persons per household: 2.61
- Households: 1,598,331
- Size of metro area: 8,043 sq. km.
- Households per square kilometer: 199

CONCLUSION

In light of the above, UWB technologies pose much less potential for causing harmful interference than suggested in the NTIA Non-GPS Study. Fantasma is committed, moreover, to working with the Commission and NTIA to ensure that any residual interference concerns are resolved so that applications using advanced UWB technology can be brought to market quickly.

Respectfully submitted,

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